A quadratic programming optimisation is used to modulate an electron beam for spatial fluence and energy by optimising the weights of overlapping beamlets. (2) The 6MV X-ray beamlet weights are optimised to cover voxels not reached by the electron beam. (3) An iterative optimisation minimises a cost function designed to incorporate the advantages and limitations of the technique. A number of optimisation methods, including evolutionary algorithms, have been evaluated for the minimisation this cost function.
Results: The algorithm has been tested for simple geometries and can produce conformal dose distributions with low dose to proximal structures and a high dose to the skin surface. In the central part of the electron field the algorithm successfully optimises the weights of electron beamlets to remove the large electron penumbra for the un-modulated beam treated through the MLC. Electron energies are selected by the algorithm to optimise the dose with depth. Target volumes not covered by the electron field are covered by the compensating photon fields
Conclusions: An IMRT mixed energy mixed modality optimisation algorithm has been developed to optimise dose with the electron field as an energy modulated boost delivered through photon MLC.

PD-0587
Beam angle optimization using derivative-free algorithms incorporating beamís-eye-view dose metrics
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Purpose/Objective: The selection of appropriate radiation incidence directions may influence the quality of the treatment plans. However, many times in clinical practice, beam directions continue to be manually selected with consumption of large amounts of time and no guarantee of optimality. Some commercial treatment planning systems are designed to use local search and/or gradient-based algorithms in the beam angle space to address the beam angle optimization (BAO) problem. Due to the many local minima aspect of the BAO problem, such approaches are not efficient. We propose a novel approach that uses beam's-eye-view ray tracing dose metrics within pattern search methods (PSM) in the optimization of the highly non-convex BAO problem.
Materials and Methods: PSM are derivative-free optimization algorithms that require few function evaluations to progress and converge and have the ability to better avoid local entrapment making them a suitable approach for the resolution of the BAO problem. PSM are organized around two phases at every iteration: one that assures convergence to a local minimizer (poll), and the other (search) where flexibility is conferred to the method allowing searches away from the neighborhood of the current iterate. Beam's-eye-view dose metrics assign a score to each beam direction and can be used within the PSM furnishing a priori knowledge of the problem so that directions with larger dosimetric scores are tested first improving results and computational time. Locally advanced head and neck clinical cases were selected to test this approach. The planning target volumes included the primary tumor, the high and low risk lymphnodes. Organs-at-risk (OARs) included the parotids, the brainstem, and the spinal cord. For each case, a setup with seven equi distant beams was choosen using CERR (computational environment for radiotherapy research). The resulting treatment plan was then compared with the plan using the optimal beam setup obtained by PSM incorporating beam's-eye-view dose metrics (PSM-BEVD).
Results: For the clinical cases retrospectively tested, the use of prior knowledge of the patient in our tailored approach showed a positive influence on the quality of the local minimizer found. The objective function value of the fluence optimization problem was reduced in average more than 10% when using the optimal beam setup obtained by PSM-BEVD instead of the traditional equidistant beam arrangement. The improvement of the local solutions in terms of objective function value corresponded to high quality treatment plans with better target coverage and with improved organ sparing.
Conclusions: PSM-BEVD has shown ability to avoid local entrapment and efficiency on the number of function evaluations leading to a fast convergence which is of the utmost importance in a busy clinical practice. Our results have shown that a global derivative-free beam angle search yields superior quality plans.

POSTER DISCUSSION: YOUNG SCIENTISTS 9: MRI AND PET IN RADIOTHERAPY

PD-0588
Validation of apparent diffusion coefficient calculation in rectal tumors
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Purpose/Objective: Recently, there has been an increased focus on using diffusion-weighted magnetic resonance imaging (DWI) to evaluate tumor response to radiotherapy (RT). The parameter used to quantify tissue diffusion is the apparent diffusion coefficient (ADC). In this work we examine some properties of the calculated ADC for rectal tumors: (i) the short term reproducibility of the ADC, (ii) how the ADC depends on the range of b-values and (iii) the dependence on scan time.
Materials and Methods: In our department, rectal cancer patients referred for concomitant chemoradiotherapy receive a pre-treatment MR scan including DWI. The DWI sequence has 11 b-values between 0 and 1100, in-plane resolution is 3x3mm and slice thickness 4.6mm. Patients have received either a single DWI scan with 4 signal averages (NSA) or two consecutive scans each with 2 NSA. Here we present data from 27 patients. Regions of interest (ROI) are drawn using a semi-automated algorithm, which, for each individual patient, selects areas exhibiting an atypically high signal. This is evaluated on the b = 1100 slices. This method provides a consistent way of defining ROIs. The ROIs defined this way corresponds well to the areas exhibiting low ADC. For each patient ADC is calculated on a voxel by voxel basis by fitting a mono-exponential function to the signal. The ADC of the ROI is then defined as the mean of the voxel ADCs over the ROI.To test (i) reproducibility, we compare the ADC between the two 2NSA scans as well as evaluating the images by eye. We also examine the effect of applying a goodness-of-fit estimation to each fitted voxel and including only voxels where a mono-exponential fit is a good description of the signal decay.Testing (ii) ADC dependency on the range of b-values and (iii) on the scan time is done by comparing the ADCs for calculations on different subsets of b-values and signal averages.
Results: We find that (i) the calculated ADCs are highly reproducible, with variations between the ADC from the first and second scan being on average 5-10% depending on the sequence of b-values used. However, individual scans can show much larger variation. Including the goodness-of-fit calculations improves the reproducibility to 2-4% and especially reduces cases of large differences. (ii) The ADC depends on the range of b-values used, showing a systematic increase as b-values shift towards lower values. This effect is mostly patient independent. (iii) We find no evidence of the number of signal averages affecting the ADC.
Conclusions: We have found that for rectal tumors the calculation of an ADC value is (i) reproducible, but to achieve the best results, and especially to avoid large deviations it is preferably to include a goodness-of-fit estimate. (ii) The calculated ADC depends on the range of b-values used. The mostly patient independent nature of this scaling suggests, that it may be possible to make a mapping between different b-value ranges. (iii) The calculated ADC does not depend on the number of signal averages.

PD-0589
Is geometrically accurate diffusion-weighted MRI of esophageal cancer possible and useful?
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Purpose/Objective: Esophageal tumours are difficult to delineate on CT images as there is no distinct contrast between healthy tissue and the tumour. Therefore, delineation is merely based on anatomical abnormalities such as wall thickening. For other tumour sites (e.g. prostate) it was shown that diffusion-weighted MRI (DWI) can improve tumour visualization. Unfortunately, DWI is prone to geometrical inaccuracies due to distortions in the main magnetic field. Those distortions are most prominent at locations with changing magnetic susceptibility (e.g. close to air/tissue boundaries). This might prove to be a problem for esophageal imaging. Aim of this work is to correct the geometrical distortions using a magnetic field distortion map and to investigate the residual errors.
Materials and Methods: Three patients eligible for neoadjuvant chemoradiation were included in this pilot study. A free-breathing DWI scan with echo-planar readout was optimized to reduce the effect of field distortions. Heavy diffusion weighting (b=800 s/mm^2) was